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ABSTRACT

Designed to introduce basic ecological relationships in a lake community, this investigation uses a Lake Erie food chain involving people and walleye as an example. The first activity is a board game in the form of a biomass pyramid; students begin with 1000 kilograms of algae and attempt to reach the "harvest" with at least a kilogram of walleye. In follow-up activities, the concepts of food web, ecological pyramid, and loss of energy between trophic levels are studied. The teacher's guide includes patterns for the game board, objectives, teaching suggestions, and a key to questions contained in the accompanying student workbook. (Author/WB)

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Ohio Sea Grant

OEAGLS- Oceanic Education Activities for Great Lakes Schools

TO HARVEST A WALLEYE

by

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Ohio Sea Grant Program
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TO HARVEST A WALLEYE

INTRODUCTION

A walleye is a large, good-tasting fish that is also a good fighter when it is caught. Because of these characterisitics, the walleye is a favorite of fisherman. In 1979, fishermen caught over 3,000,000 walleye in Lake Erie.

Lake Erie is considered by many to be the best walleye lake in North America. What does it take for a lake to produce a walleye? Why can't we catch as many walleyes in Lake Erie as we can some smaller fish?

OBJECTIVES

When you have completed these activities, you will be able to:

1. Discuss the meaning of the following terms as they relate to a biomass pyramid: producer, herbivore, 1st order carnivore, 2nd order carnivore.
2. Calculate the relative number of kilograms at each level of the biomass pyramid in a given environment.
3. Describe how different conditions in the environment affect the pyramid.
4. Compare the biomass pyramids of lake, land and ocean environments.
5. Describe how organisms are related to each other in a food web.

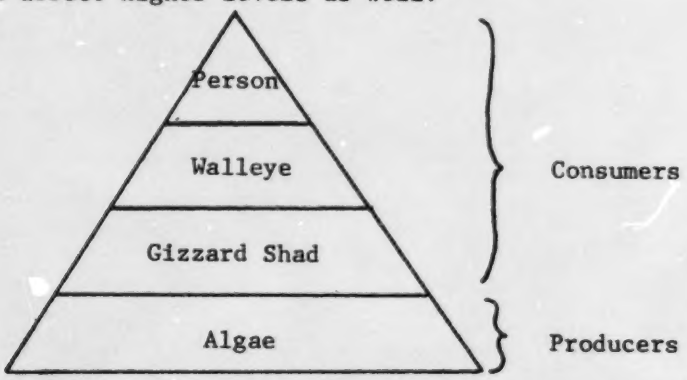
ACTIVITY A

WHO CAN HARVEST A WALLEYE?

Lake Erie is an example of a natural community. In this community the small organisms (living things) outnumber the large organisms. The smaller organisms are eaten by the larger ones. If we count all the organisms of one kind, then count all the things they eat and all the things that eat <u>them</u>, we can draw a pyramid of numbers that will also show who eats what.

In the "Walleye Game" there are four levels to the pyramid. The largest level is that of algae, the tiny water plants that produce food by photosynthesis. The other levels are all <u>consumers</u> which cannot make their own food. Gizzard shad are small fish that eat algae. Because they are plant-eaters, scientists call them herbivores. The walleye is a larger fish. There are fewer walleyes than gizzard shad, so the walleye level is smaller. Walleyes eat herbivores, so scientists say that walleyes are <u>first-order carnivores</u>. The organism that eats the first-order carnivore (a person, in this game) is called the <u>second-order carnivore</u>.

The pyramid in this game is a biomass type because it is based on the weight of the organisms in kilograms. This game shows how factors affecting lower parts of the food chain can affect higher levels as well.



The object of the game is to end at the block labeled "Harvest" with at least one kilogram (kg) of fish. You will keep track of kilograms of organisms on the "Biomass Record." The game is best played by 2-4 individuals.

MATERIALS

Walleye Game Board, Productivity Cards, Biomass Record (page 4), markers (buttons), spinner, pencil or pen.

PROCEDURE

1. Before playing game, read through the game board and Productivity Cards to pick out any words that are new to you. Look up the words in the Glossary on page 12.

2. Begin at block one with 1000 kg of algae. Spin the spinner to see who moves first. The player with the highest number will move first. Play then goes around the board to the left.

3. Move through each level of the pyramid by moving your marker the number of spaces shown on the spinner. Change your number of kilograms as the board directs. Record the new number of kg on your Biomass Record each time the mass changes.

4. Some sections of the board require you to divide the mass of the organisms by some number. Drop any fractions that you get in your answers. (Half of an organism would have a hard time surviving!)

5. At the end of each level, it is assumed that all organisms are captured by organisms of the next level. You must change columns on the Biomass Record and divide by 10 whenever you pass the algae or fish pictures, even if you don't land on them.

6. If at any time you have less than 1 kg left, you must return to block 1 and begin again.

7. The winner of the game is the first player to land at the triangle labeled "Harvest" with one kg of walleye. You must spin the exact number to land on "Harvest."

8. At the end of the game compare the results on your Biomass Record with those of the other players. Compare the kg of biomass that you had at the beginning of each level of the pyramid.

9. Discuss below some of the disasters that occurred to your organisms and how they affected your populations as you progressed through the game.

BIOMASS RECORD

PRODUCERS (ALGAE)	HERBIVORES (GIZZARD SHAD)	1ST ORDER CARNIVORES (WALLEYE)	2ND ORDER CARNIVORE (PERSON)

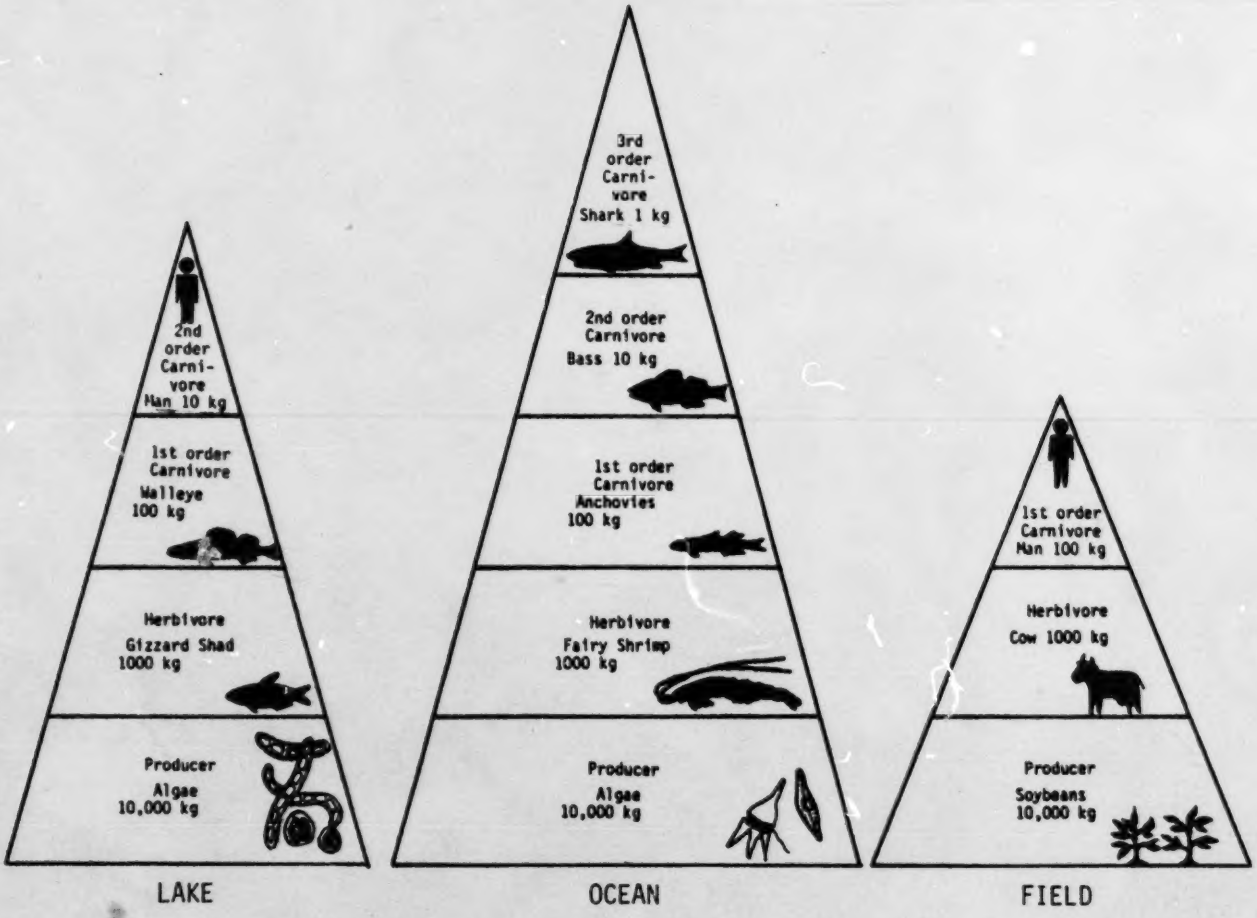
ACTIVITY B WHAT DOES A BIOMASS PYRAMID TELL US?

Although the results of the game depended on the luck of the spinner and the "Productivity Cards," many of the minor and major disasters described on the cards and on the game board actually are happening or have happened in Lake Erie. For example, on November 3, 1977, a power plant on Lake Erie killed over 600,000 fish by impingement. Most of these were gizzard shad.

At each level of a biomass pyramid energy is lost or "wasted." This is energy that cannot be passed on as food from level to level. Lost energy is one reason why it takes so much algae for so few gizzard shad and even fewer walleyes.

About 40% of the energy of algae is lost through "breathing," growing, reproducing and waste removal. Seventy-five percent of the energy of herbivores is lost through eating, breathing, waste removal, molting, growing and reproducing. First order carnivores "waste" 55% of their energy in their normal body activities. Because of this, much less energy is available for producing biomass. Therefore much less biomass ends up at the top of a pyramid.

PROCEDURE Use the following biomass pyramids to answer questions 1-3 below.


2nd order Carni-vore Man 10 kg
1st order Carnivore Walleye 100 kg
Herbivore Gizzard Shad 1000 kg
Producer Algae 10,000 kg
LAKE
3rd order Carni-vore Shark 1 kg
2nd order Carnivore Bass 10 kg
1st order Carnivore Anchovies 100 kg
Herbivore Fairy Shrimp 1000 kg
Producer Algae 10,000 kg
OCEAN
1st order Carnivore Man 100 kg
Herbivore Cow 1000 kg
Producer Soybeans 10,000 kg
FIELD

1. Count and compare the number of levels in the three pyramids. Remember, more levels mean more lost energy.

_____

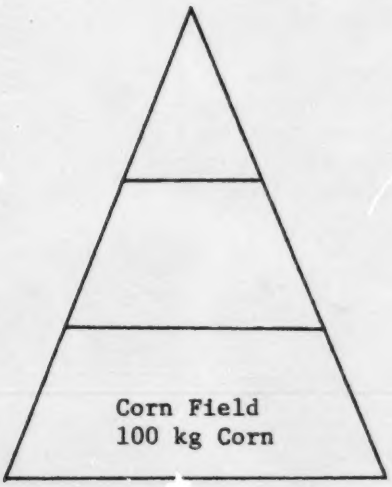
2. Which pyramid provides people with the most food?

_____

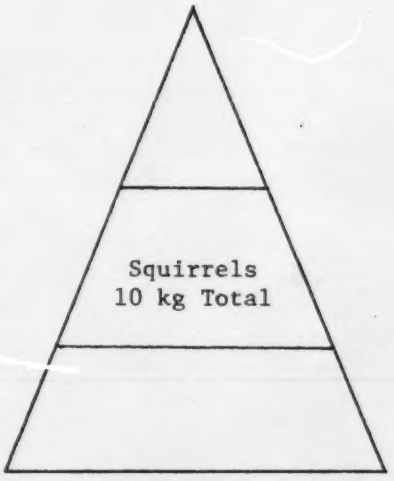
3. What might be a way of increasing the number of kilograms that people could harvest from lakes and oceans?

_____

A biomass pyramid is not just a way of showing who eats what and how much they eat. It is also a simple way of showing how different parts of an ecosystem are related. Try and fill in some species of plants or animals that would fit the food pyramids below:



FIELD



FOREST

4. Now go back and put in the amounts of each species in kilograms that would be needed to keep each level going. Assume only 1/10 of the biomass can be transferred from one level to another.

5. In the space below make up two food pyramids that you are in, based on a lettuce salad (one pyramid) and hamburgers from cattle (the second pyramid).

6. If you start with <u>equal</u> <u>amounts</u> of producers in these pyramids (10 kg) and you keep only 1/10 of the energy going from each level to the next one above it, how much biomass is available to you from the hamburger? _____

7. To have a meal that provided 1 kg of lettuce biomass, you would have to eat 1 kg of producer (the lettuce). If you ate 1 kg of hamburger, how many kg of producer would you be eating indirectly? _____

8. Which foods are usually more expensive, meats or plant products?

_____

9. A biomass pyramid is also an energy pyramid. Based on your answers to questions 4 and 5, does it make more sense to get your energy from eating organisms on low levels of a pyramid or from eating those on higher levels? _____

10. Look back at the Walleye Game. If you had to recommend a kind of fish for someone to eat that caused the least amount of energy to be wasted, which would it be? _____

11. You are stuck on a desert island with nothing on it except for three chickens and a big sack of corn. What would you do in order to get the most food energy? Give reasons. (Remember, chickens are higher on the pyramid than corn.)

_____

_____

_____

Gizzard shad are low on the Great Lakes food pyramid. Today shad are used for oil and animal protein meal which is often fed to livestock. This wastes energy from two pyramids--the shad and the cow! If we used them directly, much less energy would be wasted in reaching the top of the pyramid. Some ways that shad could be prepared for use as human food might be as fish sticks, fish cakes or a smoked product like herring or sardines.

Lake Erie isn't the only place where food is wasted because we eat "high" on the pyramid. The oceans produce much food that people never use. We boil kelp to get gelatin for things like ice cream but there are many more low level pyramid foods that we can eat.

12. Look at the food web on the next page and see if you can find anything that people could eat. List what you find below.

_____

_____

_____

ACTIVITY C WHAT IS A FOOD WEB?

A food pyramid is a very simple way of looking at a bigger picture called a food web. A food web is made up of all the different plants and animals that have an effect on one another by their feeding habits. A group of food pyramids stuck together make a food web. On the next page is a model of a food web that you might find in the ocean.

PROCEDURE

Draw arrows from the organism that is being eaten to the one that is eating. Remember that organisms on higher levels eat those on the lower levels. For instance, squid eat shrimp and anchovies, so you would draw arrows from the shrimp and the anchovies pointing to the squid. Since shrimp eat algae you would draw an arrow from the algae to the shrimp. You may use your own judgment about who eats what. Sizes of the organisms and their positions in the food chain should provide clues. There are no absolutely correct answers.

Third Order Carnivores

Size of a crow. Eats dead animals on shore and live fish.

Seagull

Bigger than a Greyhound bus.

Sperm Whale

Second Order Carnivores

Up to two meters long.

Sea Bass

Many sizes: 20cm to 3m long.

Squid

First Order Carnivores

Size of a saucer. Eats anything dead on shore.

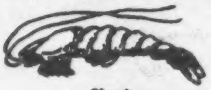
Crab

Sardine size (it comes on pizza).

Anchovy

Herbivores

Small animal 2-5 cm long.



Shrimp

Size of a man's thumb.

Mussel

Producers

Large seaweed dozens of meters long.

Kelp

Microscopic plants.

Algae

REVIEW QUESTIONS

1. List the two kinds of organisms represented in a pyramid.

_____

2. Which levels of a pyramid have "wasted" the most energy?

_____

3. If the herbivores were taken out of a food pyramid by a disaster, what would happen to the producers? The carnivores? Use your own food web an an example if you want.

_____

THINK IT OVER

If people harvested all the carnivores in a food chain, what would happen?

_____

Is it a good idea to harvest all the carnivores?

_____

GLOSSARY

1. algae bloom - situation in which algae have multiplied very rapidly.

2. breeding ground - place where organisms reproduce.

3. carnivore - animal which eats animals.

4. entrain - to suck fish up into water intake valves from industry. (Such fish are killed by temperature and pressure changes and physical abrasion.)

5. eutrophication - the natural aging process of a lake during which the lake becomes shallower and shallower and warmer and warmer, finally becoming a marshland then dry land.

6. food chain - sequence in which organisms eat and are eaten by other organisms.

7. herbicide - a chemical that kills plants.

8. herbivore - animal which eats plants.

9. impinge - to suck fish up against industrial intake sieves and hold them there causing suffocation.

10. landfill - portion of lake which is diked and filled with gravel, soil, garbage, etc. to make more land area.

11. nutrients - chemicals needed by plants and animals--fertilizers. (potassium, phosphorous, nitrogen).

12. organism - any living thing.

13. producer - plant which performs photosynthesis and forms the base of the food chain.

14. productivity - a measure of the rate of production.

15. thermal pollution - hot water.

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TEACHER GUIDE

OEAGLS Investigation #16

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TEACHER GUIDE

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INVESTIGATION — TO HARVEST A WALLEYE

OVERVIEW

This investigation is designed to introduce basic ecological relationships in a lake community, using the Lake Erie food chain involving algae, gizzard shad, walleye and man as an example. The first activity is a board game in the form of a biomass pyramid, with each of these organisms on a successively higher pyramid level. Beginning with 1000 kg of algae, students move playing pieces through the pyramid levels, encountering environmental factors which increase or decrease the amount of biomass they have. The object of the game is to reach the "Harvest" with at least one kilogram of walleye.

In follow-up activities, the ecological pyramid concept is extended to land and ocean communities, and the implications of energy loss between levels are discussed. The investigation concludes with the construction of a complete food web.

PREREQUISITE STUDENT BACKGROUND

Basic mathematical skills: addition, subtraction, multiplication and division by 10 and 2.

MATERIALS

"To Harvest A Walleye" Game Board, spinner, and Productivity Cards, all constructed from patterns in this guide; place marker tokens (buttons--one per student); record sheets (in Student Guide); paper clip; paper fastener; Activity B Worksheets.

OBJECTIVES

1. Discuss the meaning of the following terms as they relate to a biomass pyramid: producer, herbivore, 1st order carnivore, 2nd order carnivore.
2. Calculate the relative number of kilograms at each level of the biomass pyramid in a given environment.
3. Describe how different conditions in the environment affect the pyramid.
4. Compare the biomass pyramids of lake, land and ocean environments.
5. Describe how organisms are related to each other in a food web.

SUGGESTED APPROACH

Activity A is designed for groups of 2-4 players, each group with a set of game materials. For Activities B and C students can work by themselves or in small groups. Some teacher guidance may be necessary here. You may want to discuss answers to certain questions.

ACTIVITY A — TO HARVEST A WALLEYE

Keywords: algae bloom, producer, herbivore, carnivore. Glossary provided for students.

PROCEDURE

The game materials must be constructed prior to the activity. The back pages of this guide can be cut out as they are, or they can be glued to cardboard, cut out and assembled according to the guide on page 10.

Rules for the game are in the Student Guide. Thirty to forty minutes are needed to play the board game for the first time, depending on the students' proficiency in math.

After the game is completed, have the students compare Biomass Records. Ask for reasons why some have drastic cuts or increases in populations. Also compare the kg of biomass that the students had at the beginning of each level on the pyramid.

Students are asked to discuss some of the diasaters that occurred to their organisms. Even a simple repetition of the type of disaster and its effect will serve as a memory aid. Some students may go into greater explanations.

NOTE: Numbers in this game are relative and are designed to reflect reality. They were chosen to allow for simpler mathematics while indicating relative importance of the various factors affecting population.

ACTIVITY B — WHAT DOES A BIOMASS PYRAMID TELL US?

PROCEDURE

Keywords: producer, herbivore, 1st order carnivore, 2nd order carnivore, lost energy, biomass pyramid (also called a food pyramid or energy pyramid)

In this activity students answer questions based on the biomass/food pyramid presented in the board game. Answers are provided below.

1. Lake-4 levels, Ocean-5 levels, Field-3 levels.

2. The field pyramid provided the most food for people since food from lower levels of the pyramid is being utilized.

   "Ocean" is not acceptable as an answer here. Since this is the tallest pyramid students tend to think that this provides the most food. They forget that more levels means more lost food energy. This pyramid does not include people. It is an example of the many food pyramids that do not involve people.

3. Increasing the number of producers and/or harvesting lower on the pyramid would increase available kg of food. Students may have other ideas that are correct.

4. The field pyramid might be completed with pigs or cows, 10 kg, and people, 1 kg, or with squirrels, 10 kg, and bobcat, 1 kg. The forest pyramid might be completed with nuts or acorns, 10 kg, and people, 1 kg. This question is an open one, and any organisms within reason should be accepted.

5. The two pyramids ought to read from the bottom up: lettuce (10 kg), people (1 kg); and grass (10 kg), cattle (hamburger) 1 kg; people (1/10 kg).

   NOTE: Students often insert hamburgers as a separate level, not realizing that they come from cattle. Also, the math seems to confuse some students, who multiply instead of divide by 10.

6. 1/10 kg. Again, watch the math. The question asks how many kg of biomass is available to the student, not how much is in the hamburger.

7. 10 kg.

8. Meats are usually higher priced.

9. Low levels, because very little energy has been "wasted" on life processes. (Lower levels are generally less expensive, too.)

10. Gizzard shad, as it is the lowest fish on the pyramid.

11. The students ought to answer that they would eat the chickens and then the corn, since feeding corn to the chickens would waste energy. Some answers to this question can become quite elaborate. Be flexible in accepting student ideas.

12. All the plants and animals can be eaten, although seagulls are generally not.

How do people decide what they are going to eat? Ask your students. Some possible ways include the availability of the food--strawberries in season, for example. Other people will choose foods because they look good, smell good or they cost a lot and therefore, must be good! On the other hand, foods may be avoided simply because the individual parts are not recognizable (as in a quiche or casserole), or because people have heard something about the food that indicated it was not good. Maybe the animal it came from is ugly or is one that people ordinarily don't eat.

One organism in this last category is the sheepshead, or freshwater drum. The name sheepshead, as much as any other factor, has probably prevented some people from using this fish as food. As the Walleye Game has indicated, the relative abundance of the organisms on lower pyramid levels makes them attractive as a source of human food. Commercial shore seiners in Sandusky Bay can collect 40 tons of drum in one haul, according to the Ohio Division of Wildlife. Most of the drum found in commercial nets are discarded as trash fish. Few people realize that proper preparation can produce a tasty fillet. Ohio Sea Grant is now attempting to develop markets and marketing methods for the drum and other underutilized species (including gizzard shad) as human food. Those who look to the oceans as the source of food for the future would do well to look to the lakes as well!

ACTIVITY C — WHAT IS A FOOD WEB?

PROCEDURE

Kewords: food pyramid, food web

This last activity builds on Activity B by having the students draw lines between organisms that are in the same food pyramid. Since most animals eat more than one thing, a network of lines like a spider's web will result. A sample of possible connections is shown on page 6. Since there are several species of most of the organisms shown, many different webs are possible. As the Student Guide states, there are no absolutely correct answers.

Emphasize to the students that such a web is like a complex food pyramid. If one part is removed the whole system will be out of balance.

REVIEW QUESTIONS

1. Producers and consumers, or plants and animals.

2. The higher levels have energy that has passed through several levels, decreasing at each level. Hence, they have lost the most energy.

3. The producers would have a population explosion, use up all available nutrients, and die. The carnivores would starve as they cannot eat the producers. Many students answer: "They die." Have the students elaborate on and give reasons for their answer.

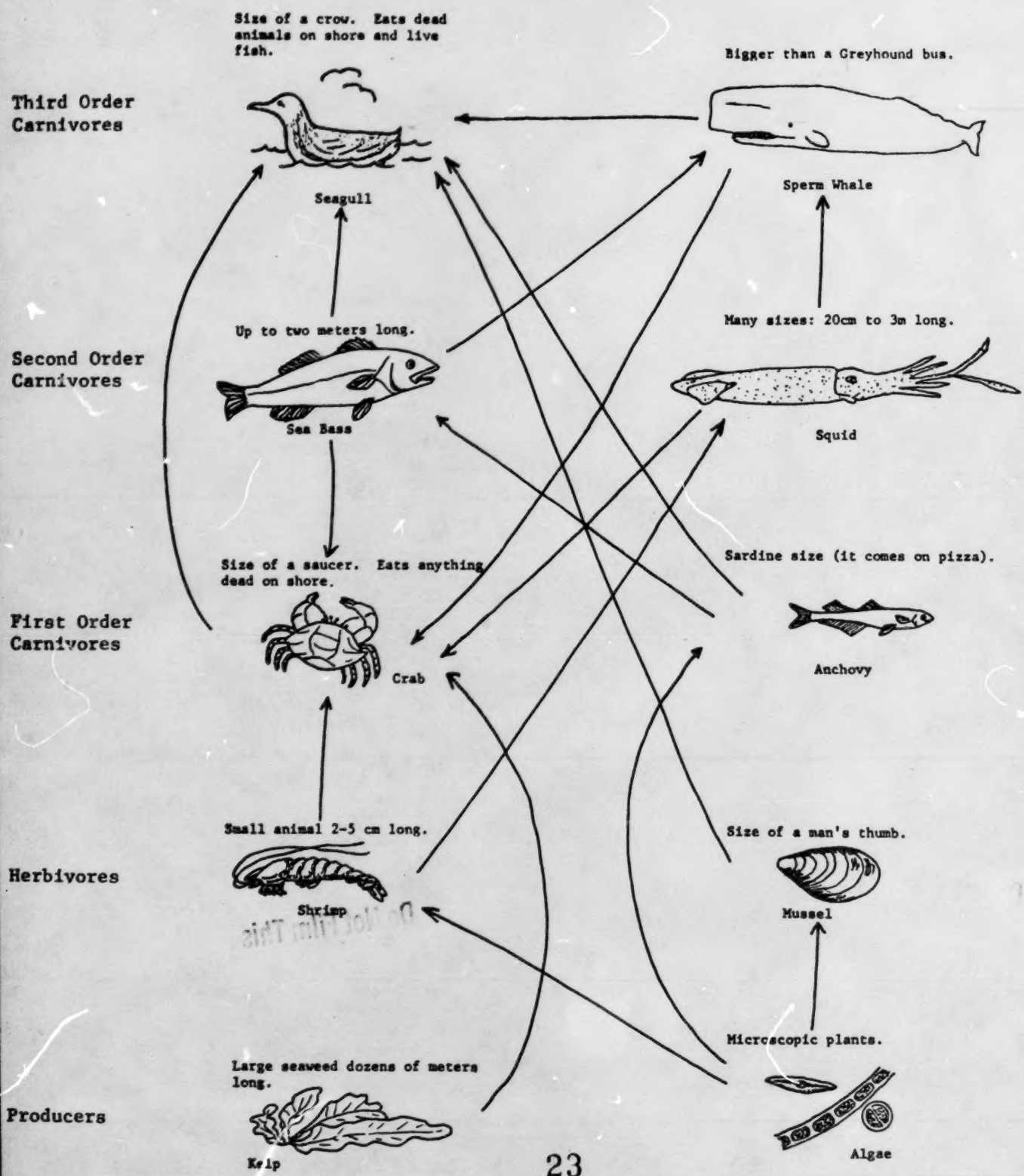
THINK IT OVER

Carnivores hold down populations of herbivores. Without this population check, herbivores would have a population explosion and eat themselves out of food. Then they would starve.

NOTE: For answers to questions 3 and "Think It Over," try to have the students make up several scenarios as examples. Accept all of them and then have the students decide which are most true to life.

EXTENSIONS

The Pete Seeger song entitled "The People Are Scratching" deals with the problem of removing organisms from the food web. Words and music are reprinted here. The song is on an album called God Bless The Grass (Columbia #CL 2432).


Third Order Carnivores
Second Order Carnivores
First Order Carnivores
Herbivores
Producers
Size of a crow. Eats dead animals on shore and live fish.
Seagull
Bigger than a Greyhound bus.
Sperm Whale
Up to two meters long.
Sea Bass
Many sizes: 20cm to 3m long.
Squid
Size of a saucer. Eats anything dead on shore.
Crab
Sardine size (it comes on pizza).
Anchovy
Small animal 2-5 cm long.
Shrimp
Size of a man's thumb.
Mussel
Large seaweed dozens of meters long.
Kelp
Microscopic plants.
Algae

REFERENCES

Almost all biology and ecology texts will have some reference to food chains, pyramids and webs. The texts below also have extensive reference systems.

Abraham, Norman, Richard G. Beidleman, John A. Moore, Michael Moores, William J. Utley, Interaction of Man and the Biosphere; Inquiry in Life Science, Teachers Edition, Second Edition Rand McNally and Co. Chicago, 1975, B.S.C.S. Green, pp. 177F-181B.

Odum, Eugene P. Fundamentals of Ecology, 3rd ed., W. B. Saunders Co. Philadelphia, 1971, pp. 63-85. Reference is technical and not recomended for use by students. However, it supplies much additional factual material.

Rasmussen, Frederick A., Paul Holobinko and Victor M. Showalter; Man and the Environment. Houghton Mifflin Co. Boston, 1971, pp. 186-189, 205-209 additional activity, 201 explanation.

Ohio Department of Natural Resources, Publication 185. "Gizzard Shad in Ohio." Life History Notes.

_____, Publication 141. "Yellow and Blue Walleye in Ohio." Life History Notes.

_____, Division of Wildlife, Publication 7. "Water Pollution, Fish Kills and Stream Litter Investigations, 1977."

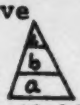
EVALUATION ITEMS

1. A plant is eaten by a herbivore, and the herbivore is eaten by carnivore. This set of relationships is called a(n)

   (1) menu.
   (2) eating cycle.
   (3) food chain.
   (4) food web.

2. How is energy "wasted" by the different levels of a biomass pyramid?

   (1) breathing and respiration
   (2) eating and excreting wastes
   (3) growing and reproducing
   (4) all of the above

3. If this structure, 

, represents a biomass pyramid, how much of the biomass of a is available to be used by the organisms of b?

   (1) 1/5
   (2) 1/10
   (3) 1/4
   (4) 1/2

4. Which biomass pyramid would be more efficient at providing people with food? (NOTE: People are at the top of each pyramid.)

   (1)
   (2)
   (3)
   (4)

5. In harvesting a walleye from Lake Erie, a person becomes part of which food chain?

   (1) algae → gizzard shad → walleye → person
   (2) seaweed → minnows → carp → walleye → person
   (3) carp → algae → walleye → person
   (4) water plants → walleye → person

6. In order to feed more people, we should try harvesting

   (1) plants and animals that are lower in food chains.
   (2) more meat and fewer vegetables to eat.
   (3) raising more sheep and fewer cows.
   (4) harvesting as many walleyes as possible.

7. Why is there less energy available to top carnivores than to lower order consumers?

   (1) Energy is "wasted" by body processes of the lower organisms.
   (2) Top carnivores can't eat as much as herbivores.
   (3) Top carnivores do not need as much energy to live.
   (4) There are too many top carnivores.

8.

In the biomass pyramid shown, how many kg of producers are needed to support 1 kg of man?

(1) 10
(2) 100
(3) 1000
(4) 10000

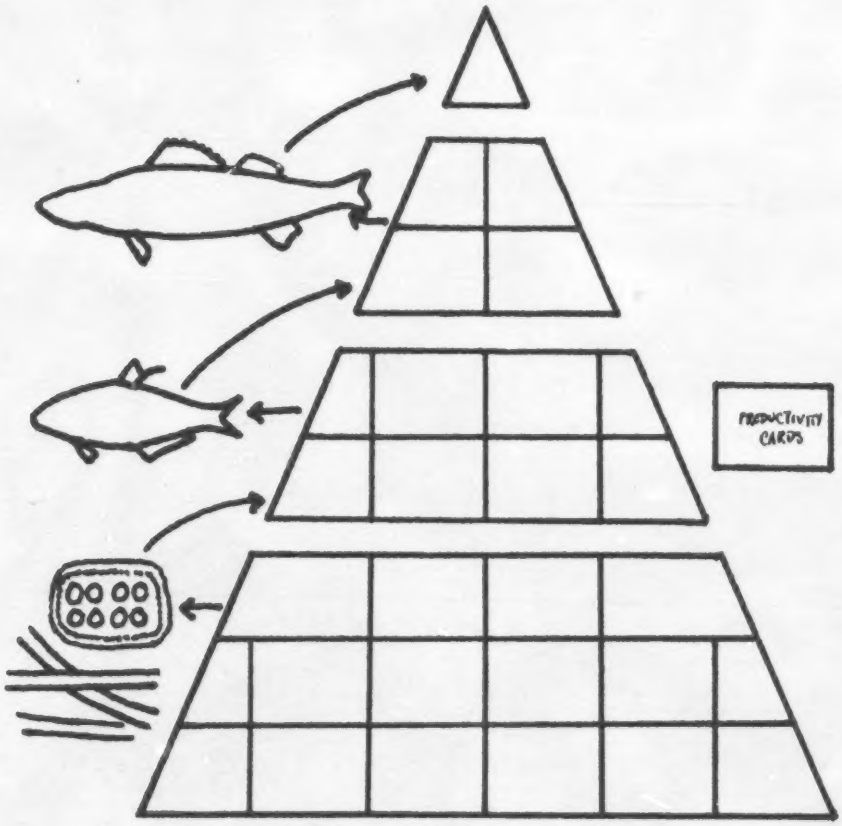
9. Where do humans usually fit into a biomass pyramid?

(1) at the top
(2) in the middle
(3) at the bottom

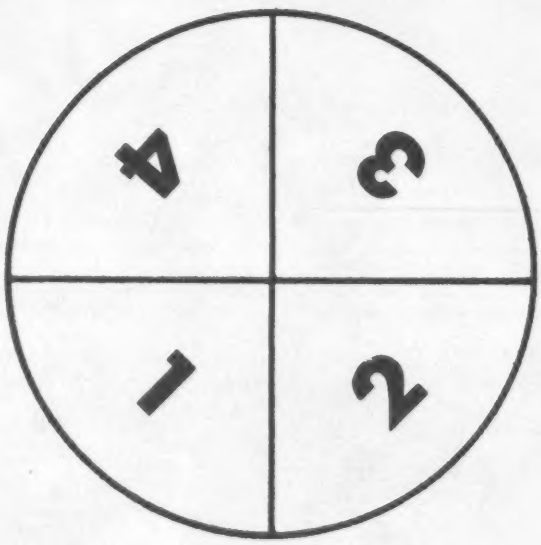
10. What is a group of food chains stuck together called?

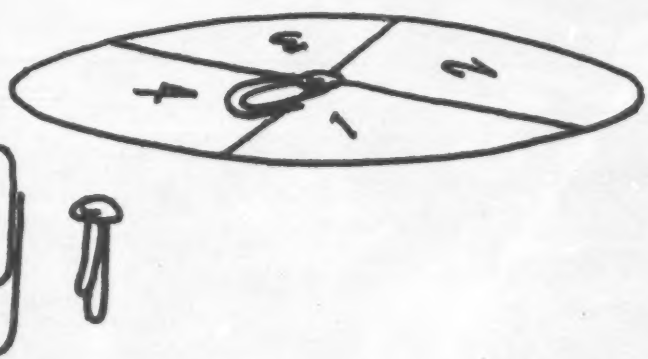
(1) eutrophication
(2) a food web
(3) productivity
(4) an environment

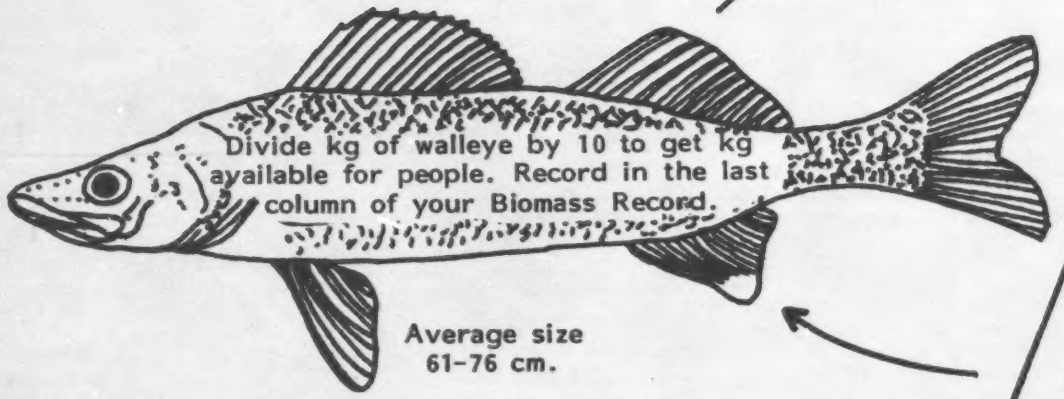
The game board should look like this when finished.



Cut out the spinner and paste it on a piece of cardboard. You will need a paper clip and a paper fastener to assemble as shown.






Divide kg of walleye by 10 to get kg available for people. Record in the last column of your Biomass Record.
Average size 61-76 cm.

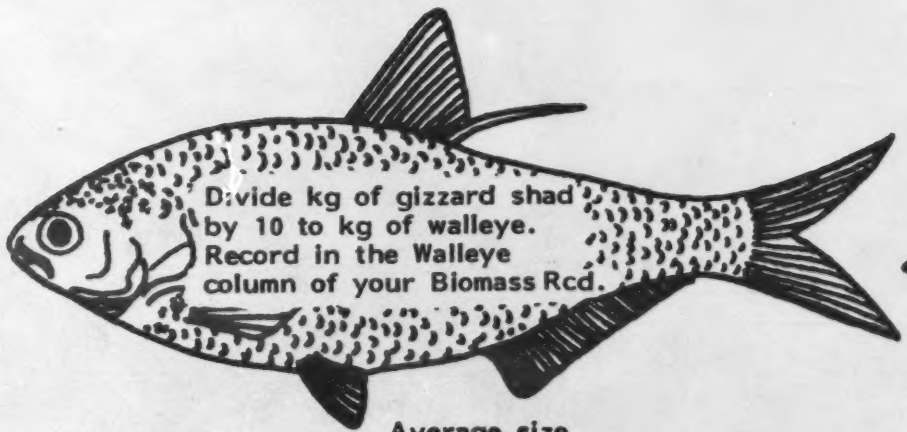
HARVEST. A person becomes a second order carnivore.

Thermal pollution kills all but 10 kg.

Commercial Fisheries from Canada catch ½ your walleye.

Sport fishing catches ½ your walleye.

Spawning. Multiply 10X.



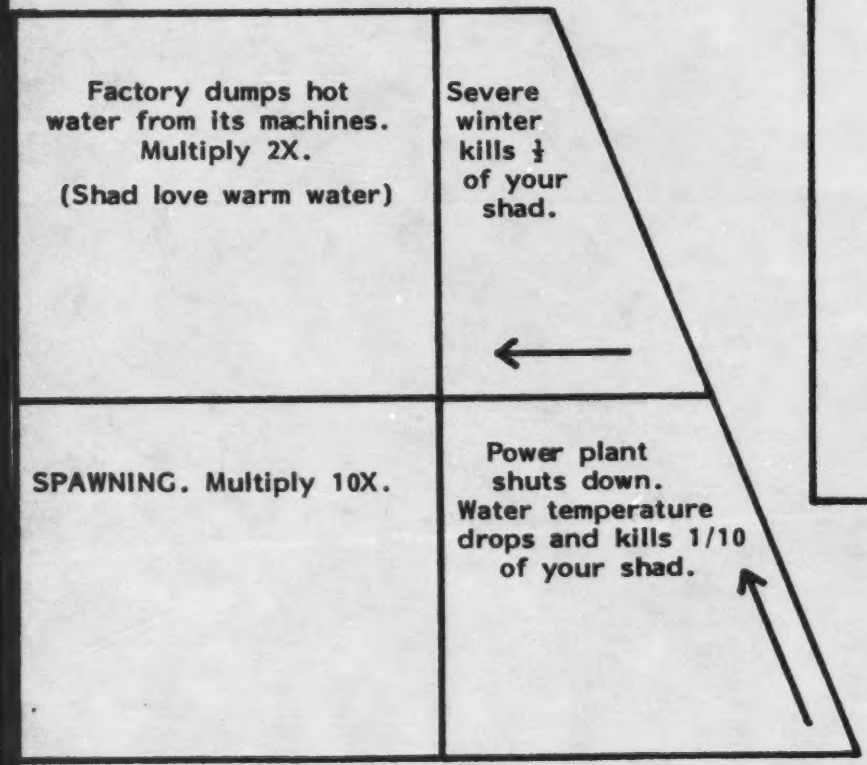
Average size 30-38 cm.

Algae bloom uses up O_2. All but 25kg die.

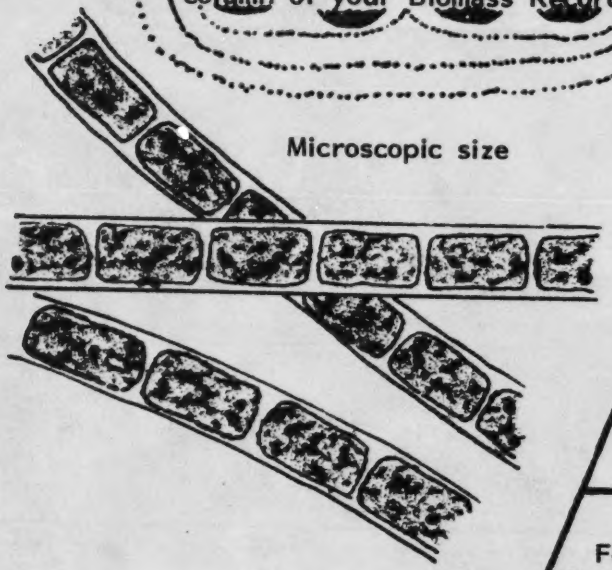
Breeding grounds wiped out by landfill. Lose ½.

Power plant impinges and entrains shad. Lose ½.

Kingfishers, herons and other fish-eating birds eat 10 kg. of your shad.


Factory dumps hot water from its machines. Multiply 2X.
(Shad love warm water)
Severe winter kills ½ of your shad.
SPAWNING. Multiply 10X.
Power plant shuts down. Water temperature drops and kills 1/10 of your shad.

PRODUCTIVITY CARDS



Microscopic size

Djvide kg of algae by 10 to get kg of gizzard shad. Record this number in the Herbivore column of your Biomass Record.

Chemical pollution reduces population by 50 kg.

Draw a productivity card.

Silt from spring floods blocks sunlight. ½ algae die.

Microscopic animals eat ½ your algae.

A new phosphate detergent makes billowy suds on the lake. Algae bloom but only 1/10 survive due to oxygen lack.

Fertilizer runoff from fields increases algae nutrients. Multiply 20 times.

Draw a productivity card.

Algae bloom uses up oxygen and nutrients. Lose ½ your algae.

Fish and other animals from another food chain eat 50kg of your algae.	Lake freezes. Ice and snow block sunlight. All but 100kg die.	
An oil spill cuts down on sunlight and as it settles kills 60kg of algae.	Flooding makes sewage treatment plants on Maumee & Portage Rivers dump raw sewage. Multiply 20 times.	Hungry herbivores eat 1/10 of your algae.
SPRING! Begin growing season - multiply algae kg. by 10.	Thermal pollution causes algae bloom. Multiply by 10.	START Begin with 1,000 kg. phytoplankton (algae) producing food.

Land fill. Breeding grounds are destroyed. Lose all organisms. Go back to block 1 and begin with 1,000 kg algae.

Grass carp (herbivorous fish from another food chain) are introduced into Lake Erie. They eat ½ your algae.

Save this card until you need it. Coast Guard saves the day and cleans up the oil spill. You lose only ½ your algae.

Algae that died in another bloom start to decay and release nutrients into the water. Add 50 kg.

Army Corps of Engineers stops dumping dredging spoils into the lake. Add 50 kg.

A power plant dumps hot water killing all except blue-green algae. Lose 200 kg.

Eutrophication speeds up in the Western Basin of lake. Lack of oxygen kills all but 100 kg.

Pollution from the Cuyahoga River enters the lake. Lose 100 kg organisms.

ORGANISMS DOUBLE !!

Tanker grounds on shoal dumping sulfuric acid. Lose 100 kg.

Oil spill. Lose all organisms. Go back to block 1; begin with 1,000 kg algae.

Sewage treatment plant opened with better cleaning equipment. Lower nutrient levels result because there is less sewage pollution. Lose 50 kg.